GDT 69

A. Scope

For a complete list of GDTs, see the Table of Contents.

Use these eight specific test procedures to evaluate the effectiveness of Waterproofing Membranes for Concrete Bridge Decks and to determine which may be most likely to perform well in the field.

1. Bond Test (Qualitative)—No scope is defined.
2. Water Permeability Test (Electrical Resistance)—If the membrane is not fabricated from an electrical conducting material, the water permeability of a membrane is inversely proportional to its electrical resistance. Permeability can therefore be measured indirectly in terms of ohms per square foot (square meter).

   The membranes are classified in terms of electrical resistance as follows:

Resistance (ohms per square foot)	Rating
Greater than 10^6	Good
10^6 to 10^4	Fair
10^4 to 10^2	Poor
Less than 10^2	Very Poor

   The lowest acceptable value for a bridge membrane resistance is five hundred thousand (5×10^5) ohms per square foot.
3. Heat Resistance Test—Since a bridge deck membrane is covered with a hot asphaltic concrete overlay, the membrane must be able to withstand temperatures of around 300 ^{o}F. Use this test to determine if those temperatures have an appreciable effect on the permeability of the membrane.
4. Resistance to Aggregate Penetration (Creep Damage)—Use this test to determine the potential of the membrane to be damaged by aggregate penetrating from the overlying asphaltic concrete wearing course.

   Perform this test on a specimen that has already passed through a Heat Resistance Test.
5. Resistance to Freezing and Thawing Cycles—Membranes are only placed in areas with winter conditions severe enough to require frequent, concentrated applications of de-icing salts. Membranes must be able to withstand repeated freezing and thawing.

   Judge the effect of freezing and thawing by comparing the initial readings of tensile strength and elongation at break with values for the same type of membrane that has undergone freezing and thawing cycles.

   Use this test to determine which membrane can be expected to perform best under freezing and thawing conditions.
6. Chemical Resistance Test—The membrane should remain intact and in good condition when immersed for 30 days in each of the following inorganic acids, alkalis, and salts:
   - 5% sulfuric acid
   - 5% hydrochloric acid
   - 5% sodium hydroxide
   - 25% sodium chloride
   - 25% calcium chloride
7. Shear Resistance Test—Use this test to determine the potential of the complete membrane system to be damaged by a hot asphaltic concrete overlay and the potential to resist shear forces.

   Perform the test on a specimen that has not been tested before.
8. Waterproofing Effectiveness Test—Use this test to determine the potential of the complete membrane system to be damaged by a hot asphaltic concrete overlay and the potential to resist damage to the waterproofing effectiveness.

B. Apparatus

The apparatus used depends on the test procedure chosen.

1. Bond Test

   No equipment specified.

2. Water Permeability Test
   a. Metal Pan: Use a pan large enough to hold sample block.
   b. Wetting Agent: Use detergent and water, 0.7 oz per gallon (5.3 ml per liter).
   c. Ohmmeter: Use on with a 0 to 10^6 ohms capacity.
   d. Electrode: Use an electrode consisting of a 6 in x 6 in x 1/8 in (150 mm x 150 mm x 3 mm) copper plate and a 6 in x 6 in x 1 in (150 mm x 150 mm x 25 mm) cellulose sponge.
3. Heat Resistance Test
   a. Oven: Use a forced-draft oven.
   b. Electrical Resistance Test Equipment
4. Resistance to Aggregate Penetration (Creep Damage)
   a. Oven: Use an oven that circulates air at 140 °, ± 2 °F (60 °, ± 1 °C).
   b. Rubber Pad: Use a pad with a Shore Hardness A, and of dimensions 62 in (± 2 in) x 6 in x 1/8 in (1575 mm (± 50 mm) x 150 mm x 3 mm).
   c. Wood Template: Use a 7 x 3/8 in (178 mm x 10 mm) piece of wood with a centered, 5 in (125 mm) square opening
   d. Plywood Block: Use a 6 in x 6 in x 1/2 in or 3/4 in (150 mm x 150 mm x 13 mm or 19 mm) block.
   e. Concrete Cylinder: Use a cylinder 12 in (300 mm) long by 6 in (150 mm) diameter.
   f. Watsonville Granite Chips: Use chips that pass a 3/8 in (10 mm) sieve and are retained on a No. 3 (5.7 mm) sieve.
   g. Metal Jackstones: Use four stones.
   h. Electrical Resistance Test Equipment
   i. The concrete cylinder, wooden block, and rubber pad should have a total weight of 30 lbs, ± 1 oz (14 kg, ± 28 g).
5. Resistance to Freezing and Thawing Cycles

   No equipment specified.

6. Chemical Resistance Test

   No equipment specified.

7. Shear Resistance Test
   a. Marshall Apparatus
   b. Split Ring Collar
   c. Compression Machine: Use a machine with a small diameter swivel head.
   d. Steel Plate: Use a 1-1/2 in (38 mm) wide, 2in (50 mm) radius, semi-circular plate
   e. Metal Template: Use a 6 in x 6 in x 1/4 in (150 mm x 150 mm x 6 mm) template.
8. Waterproofing Effectiveness Test
   a. Electrical Resistance Test Equipment
   b. Diamond Blade Saw

C. Sample Size and Preparation

Prepare concrete blocks as follows:

1. Use blocks that are 2 in x 7 in x 13 in (50 mm x 175 mm x 325 mm).
2. Use a concrete mix containing 585 lbs of cement per cubic yard (348 kg/m^3) of concrete, not more than 36 gal per cubic yard (177 liters per cubic meter) of water, and 5.5 percent entrained air.
3. Ensure the mix produces a consistency of 3 to 4 in (75 to 100 mm) slump.
4. Trowel the surface to give a medium smooth finish.

5. Moist-cure all blocks at a minimum of 90 percent relative humidity for 7 days.
6. Permit the blocks to dry at room temperature before preparing the blocks for the waterproofing membrane.
7. Apply and cure the membrane system in accordance with the manufacturer's recommendations.

D. Procedures

1. Bond Test (Qualitative)
   a. Before performing any other tests on a block, check the bond of the membrane to the block by attempting to lift the edges of the membrane.
   b. Record any absence of bond, curled edges, bubbles, etc.
   c. After the membrane system has completely cured, make a 1 in x 1 in (25 x 25 mm), L-shape cut through the membrane near the edge of the block and attempt to lift the corner of the cut with a knife point. Be sure to make the cut in a place that will not interfere with the creep damage test.
   d. Record a subjective evaluation of the bond.
2. Water Permeability Test (Electrical Resistance)
   a. Place a membrane and concrete block specimen in a metal pan.
   b. Fill the pan with water to 1/4 in (6 mm) below the bottom of the membrane.
   c. Saturate a cellulose sponge with a wetting agent and place it on the membrane. Avoid wetting the outside 1/2 in (13 mm) border of the membrane.
   d. Let the membrane soak for 20 minutes.
   e. Place the copper plate on top of the sponge and check the electrical resistance between the copper plate and the pan.
   f. Rotate the electrical resistance between the copper plate and the pan.
   g. Rotate the electrode on top of the block 180 degrees and repeat the resistance measurement.
   h. If the ohmmeter is of the magnitude of 10^2 or 10^3 ohms, reverse the ohmmeter leads and repeat the measurement.
   i. Average the values if they are different.
   j. For low resistance membranes, you may expect inaccurate readings if the metal pan is not copper, since the pan and the copper electrode plate will form an electrical cell that will generate sufficient voltage to change the ohmmeter readings. The effect of this voltage will be negligible for readings on high resistance membranes.
3. Heat Resistance Test
   a. Determine the initial electrical resistance of a membrane and concrete block specimen.
   b. Put the sample in an oven preheated to 300 °F (149 °C) and leave the heat and fan on for 12 to 15 minutes until the temperature returns to 250 °F (121 °C).
   c. Shut off the oven and allow it to cool to 100 °F (38 °C), about 2 hours.
   d. Remove the specimen and allow it to cool to room temperature.
   e. Determine the electrical resistance.
4. Resistance to Aggregate Penetration (Creep Damage)

   This is a two part test consisting of a moderate conditions test (A) and a severe conditions test (B). Both tests should be done only on blocks that have passed a heat resistance test.
   a. Test A (Moderate Conditions):
      1) Determine the electrical resistance of the specimen.
      2) Place the specimen on the oven shelf and put the template on the specimen.
      3) Distribute 0.29 lbs (130 grams) of granite chips evenly over the membrane within the template.
      4) Remove the template and place the rubber pad, plywood block, and concrete weight in position on top of the granite chips.
      5) Close the oven, turn on the fan, and heat to 140 °, ± 2 °F (60 °, ± 1 °C).
      6) Maintain that heat for 20 hours.

    7) Remove the specimen from the oven and remove weight, block and pad.
    8) Tilt or invert the specimen to dump the chips that do not adhere to the membrane.
    9) Record whether stones adhere or are embedded, and any visible damage.
    10) Measure the electrical resistance.

b. Test B (Severe Conditions):

   This procedure is the same as A except that you use four jackstones in the template opening, one near each corner, instead of the granite chips.

5. Resistance to Freezing and Thawing Cycles
   a. Determine the tensile strength and elongation at break by ASTM D 412, D 638, or C 190 (depending on the nature of the membrane).
   b. Prepare three specimens that conform to the requirements of the ASTM Methods.
   c. Punch a 1/8 in (3 mm) diameter hole near each of the specimens.
   d. Assemble the specimens on glass or end wooden rods with at least 1/4 in (6 mm) spacing between the specimens.
   e. Run them through 10 cycles of the following:
      1) Immerse specimens in distilled water at room temperature and place covered containers in a room or oven at 140 °, ± 2 °F (60 °, ± 1 °C) for 15 hours.
      2) Transfer specimens into distilled water with a temperature of 40 °F (4.5 °C) and freeze at 0 °, ± 2 °F (–18 °, ± 1 °C) for 9 hours.
      3) Allow frozen specimens to thaw and remain immersed at room temperature for 15 hours.
      4) Remove specimens from water and place in oven at 140 °, ± 2 °F (60 °, ± 1 °C) for 9 hours.
   f. After 10 cycles, subject the specimens to the appropriate ASTM test.
   g. Compare the results with those of similar samples of the same membrane that have not been frozen.
6. Chemical Resistance Test
   a. Immerse the membrane in solutions made for each of the following for 30 days:
      - 5% sulfuric acid
      - 5% hydrochloric acid
      - 5% sodium hydroxide
      - 25% sodium chloride
      - 25% calcium chloride
7. Shear Resistance Test
   a. Form laboratory specimens of the complete membrane system and hot bituminous pavement overlay on concrete blocks prepared as instructed in Sample Size and Preparation. Apply the membrane system in strict accordance with the manufacturer’s recommendations, including application rates for primer, components temperatures, and curing.
   b. Form two, 4 in (100 mm) diameter by 2-1/2 in (63 mm) hot bituminous pavement specimens on the prepared membrane in the following manner:
      1) Use the Marshall Design Procedure Apparatus (ASTM D 1559) to form a hot bituminous pavement mix specimen.
      2) Preheat the compaction mold, base plate, and collar to 275 °F (135 °C).
      3) Wipe a light film of oil on the inside surface of the split ring collar.
      4) Mold the mix at 275 °F (135 °C).
      5) Place a metal template that is 6 in x 6 in x 1/4 in (150 mm x 150 mm x 6 mm) with a 4-1/4 in (106 mm) diameter hole on the prepared membrane. The template also has a preheated split-ring collar centered over the template hole.
      6) Immediately transfer the mold and mix to the prepared membrane.
      7) Place the molded specimen on the split ring collar and place a preheated follower on top of the specimen.

8) Slide this assembly into the compression machine and press the specimen into contact with the membrane.
9) Apply two quick, 2500 lb (11 121 N) static loads, releasing the pressure to zero between loads.
10) Release the pressure and slide the slab from under the compression machine head.
11) Carefully remove the split-ring collar and template. You may need to place the steel follower on top of the specimen and hold it by hand while removing collar and template in order not to disturb the specimen.
12) Mold the second specimen on the membrane in the same manner as the first.
13) Allow both specimens to cool to room temperature.
14) Determine the bonding effectiveness of the complete membrane system.
15) Subject one of the molded bituminous specimens to a direct shearing force parallel to the surface of the membrane.
16) Stand the concrete block on one side.
17) Place a 1-1/2 in (38 mm) wide, semi-circular steel plate with at least a 2 in (50 mm) radius, on top of the specimen to be sheared.
18) Slide the assembly into position in the compression machine fitted with a small diameter swivel head.
19) Align the specimen so that the swivel head is as close as possible to the semicircular plate without touching it.
20) Apply a steady load at approximately 1/4 in (6 mm) per minute until failure occurs.
21) Continue pressing after failure to observe the type of bond and exactly where the failure occurred.
22) Record the total number of pounds (newtons) at failure as the force necessary to shear the weakest portion of the membrane system. This may occur between the concrete block and membrane, between the membrane and bottom of the asphaltic pavement specimen, in the membrane, or in the pavement specimen.
    a. Where and how the shear failure took place is as important as the actual number of pounds (newtons) required for failure. A system with a high shear resistance but poor elasticity may be less effective than one with less resistance but more integrity.
    b. Thoroughly analyze any system that shears at less than 100 lbs (449 N).

8. Waterproofing Effectiveness Test
    a. Saturate the second prepared membrane specimen (from step 7.b) by slowly applying water to the top surface until you observe free water seeping from the bottom of the specimen close to the membrane. Use a small amount of wetting agent in the water to facilitate this process.
    b. If the specimen does not readily absorb the water, you may need to build a dam around the outside of the specimen.
    c. Use a strip of heavy waxed paper, held in place with rubber bands.
    d. Seal the contact of the paper and specimen with catalytically blown asphalt diluted to a thick paint consistency with a volatile solvent.
    e. After the specimen is thorough saturated, test for electrical resistance as described in step 2.
    f. Place a 2-3/4 in (69 mm) square by 1/2 in (13 mm) thick piece of thoroughly wet sponge on top of the saturated specimen.
    g. Place a 2-3/4 in (69 mm) square by 1/8 in (3 mm) thick copper plate on top of the sponge.
    h. Check the electrical resistance between the copper plate and the pan.
    i. Do not allow water that has seeped through the specimen to run over the edge of the membrane onto the concrete block.
    j. Thoroughly investigate any laboratory specimen with an electrical resistance of less than 1 million ohms.
    k. Using a diamond blade saw, cut through this specimen and concrete block.
    l. Examine the contact for resistance to puncture by the aggregate and integrity of the membrane to resist displacement.

E. Calculations

A successful laboratory evaluation alone does not constitute approval of the complete membrane-pavement system. Final approval will be subject to the Engineer’s evaluation of the practicality of construction techniques.

F. Report

Report the results of each test on the appropriate forms.